The H.E.S.S. Experiment

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Abstract. The High Energy Stereoscopic System (H.E.S.S), a third-generation array of atmospheric-Cherenkov telescopes, is used to perform searches for VHE (>100 GeV; Very High Energy) γ-ray emission from astrophysical objects with unprecedented sensitivity (5σ detection of a 1% Crab flux source in $\sim$25 hours of observation). Prior to the commencement of H.E.S.S. observations, only $\sim$10 sources of VHE γ-rays were known. With the recent detections by H.E.S.S. of more than 30 sources of VHE γ-rays, from a number of source classes, the understanding of the VHE sky has dramatically improved.

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The H.E.S.S. experiment, located in the Khomas Highlands of Namibia (23° 16' 18" S, 16° 30' 1" E, 1800 m above sea level), is designed to search for astrophysical γ-ray emission above $\sim$100 GeV up to $\sim$100 TeV. H.E.S.S. detects the flashes of Cherenkov light emitted from the electromagnetic cascade of secondary particles (EAS; Extensive Air Shower) resulting from the initial interaction of a γ-ray primary in the upper atmosphere. The detector consists of a system of four imaging atmospheric-Cherenkov telescopes (diameter 13 m, focal length 15 m, mirror area 107 m^2) in a square of 120 m side. The optics [1, 2] are of good quality resulting in a small point spread function (width<0.1°) across the whole field of view (f.o.v). The H.E.S.S. cameras [3] are modular in design and contain all the necessary electronics for operation, triggering, and readout. Each camera contains 960 individual photomultiplier (PMT) pixels subtending 0.16° each, with Winston cone light concentrators, providing a 5° f.o.v. with a uniform response. A central trigger system [4] is used to require a multiple telescope coincidence (a minimum of two triggered telescopes) allowing for stereoscopic reconstruction of the EAS observed simultaneously by the telescopes. More details on H.E.S.S. can be found in [5] (review), [6] (calibration), and [7] (analysis & performance).

The energy threshold of H.E.S.S. at zenith is 100 GeV before selection cuts and remains below 1 TeV (after the standard selection cuts) for zenith angles (Z) less than 60° within which almost all H.E.S.S. observations are performed. The amount of observation time (live hours), at Z=20°, required to detect (>5σ) a source for a range of fluxes is shown in Figure 1. For comparison to the previous generation of VHE instruments, HEGRA needed $\sim$100 hours to detect 5σ from a 5% Crab Nebula strength source, whereas H.E.S.S. only needs 1 hour of observations. H.E.S.S. has an average energy resolution of $\sim$15% per event allowing for an accurate determination of a detected source's energy spectrum above the post-cuts energy threshold [7]. The systematic error on the photon index of a power-law fit to a measured spectrum is estimated to $\sim$0.1 and the systematic error on the observed integral flux (or upper limit) is $\sim$20%.

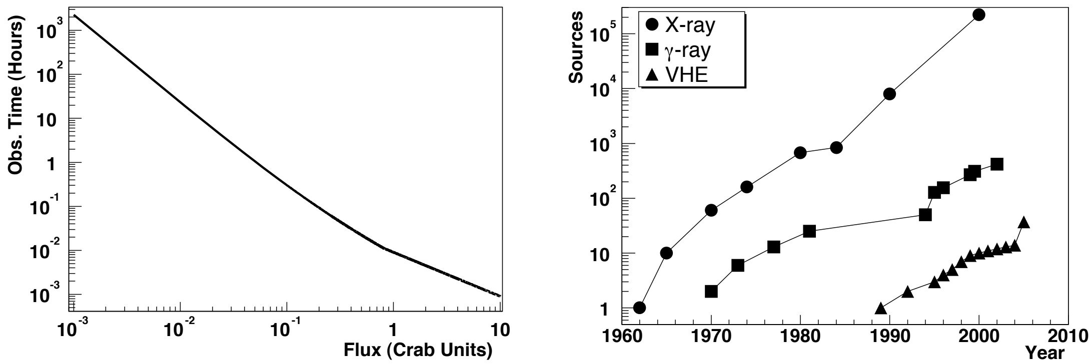

FIGURE 1. (Left) The observation time required to yield a 5σ detection at Z=20° *vs.* fraction of the Crab Nebula flux. (Right) The "Kifune plot": Shown are the number of detected sources in X-rays, lower-energy γ-rays, and VHE γ-rays versus time.

The unprecedented sensitivity of H.E.S.S. has allowed it to achieve many ground-breaking results. Among these is the detection of >30 sources of VHE γ-rays, from a variety of new and different source classes. Table 1 shows the sources published by H.E.S.S. Only $\sim$10 sources of VHE γ-rays were known prior to the commencement of H.E.S.S. observations. In addition, all sources detected by H.E.S.S. are published with studies of their measured energy spectra and flux/spectral variability, allowing for detailed theoretical modelling of the non-thermal processes at work in the objects. Another achievement is the ability to perform, for the first time, high-resolution mapping of extended regions of the sky in VHE γ-rays (see e.g. [19]). This is enabled by the combination of the large f.o.v., the small angular resolution (<0.1°), and low absolute pointing error (<20" in each direction) of H.E.S.S., allowing for detailed studies of VHE source morphology, as well as making H.E.S.S. ideal for performing surveys for unknown VHE gamma-ray sources [17, 18]).

With VHE observations being performed by H.E.S.S., as well as by other third-generation VHE atmospheric-Cherenkov instruments such as VERITAS, MAGIC and CANGAROO-III, it is clear that the future of VHE γ-ray astronomy is bright. Should VHE astronomy progress similarly to X-ray astronomy or lower-energy γ-ray astronomy, the number of sources is expected to increase dramatically as shown in Figure 1.

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TABLE 1. The H.E.S.S. source catalog: associations, source class, and references are shown. For all the Scan sources, the associations are based on positional coincidence(s) and therefore should only be considered as possible counterparts. The source class acronyms are Active Galactic Nucleus (AGN), Pulsar Wind Nebula (PWN), Supernova Remnant (SNR), X-ray Binary (XRB) and unidentified (UID).

Name	Association	Source Class	Ref.
HESS J0534+220	Crab Nebula	PWN	[8]
HESS J0835−456	Vela X	PWN	[9]
HESS J0852−463	RX J0852.0−4622 (Vela Jr)	SNR	[10]
HESS J1103−234	1ES 1101−232	AGN (BL Lac)	[11]
HESS J1104−382	Mkn 421	AGN (BL Lac)	[12]
HESS J1230+123	M 87	AGN (FR I)	[13]
HESS J1302−638	PSR B1259−63 / SS 2883	Binary	[14]
HESS J1303−631	?	?	[15]
HESS J1514−591	MSH 15−52 / PSR B1509−58	PWN	[16]
HESS J1614−518	?	Scan	[17]
HESS J1616−508	PSR J1617−5055	Scan (PWN)	[17]
HESS J1632−478	IGR J16320−4751	Scan (XRB)	[18]
HESS J1634−472	IGR J16358−4726 / G 337.2+0.1	Scan (XRB/SNR)	[18]
HESS J1640−465	G 338.3−0.0 / 3EG J1639-4702	Scan (SNR/UID)	[17]
HESS J1702−420	?	Scan	[18]
HESS J1708−410	?	Scan	[18]
HESS J1713−381	G 348.7+0.3	Scan (SNR)	[18]
HESS J1713−397	RX J1713.7−3946	SNR	[19]
HESS J1745−290	Sgr A* / Sgr A East?	Galactic Center	[20]
HESS J1745−303	3EG J1744−3011	Scan (UID)	[18]
HESS J1747−281	G 0.9+0.1	PWN	[21]
HESS J1804−216	G 8.7−0.1 / PSR J1803−2137	Scan	[17]
HESS J1813−178	G 12.82-0.02	Scan (SNR)	[17]
HESS J1825−137	PSR J1826−1334 / 3EG J1826−1302	Scan (PWN/UID)	[17]
HESS J1826−148	LS 5039	Microquasar	[22]
HESS J1834−087	G 23.3−0.3	Scan (SNR)	[17]
HESS J1837−069	AX J1838.0−0655	Scan (UID)	[17]
HESS J2009−488	PKS 2005−489	AGN (BL Lac)	[23]
HESS J2158−302	PKS 2155−304	AGN (BL Lac)	[24]
HESS J2359−306	H 2356−309	AGN (BL Lac)	[11]

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